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A quantitative, volumetric and dynamic study of the vegetation of the Pinus Taeda belt of Virginia and the Carolinas

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(WITH ONE TEXT FIGURE)

Introduction. The study of the vegetation of a given region may conveniently be divided into four stages. First, the various species of plants are collected, described (if necessary), and classified taxonomically, and their local distribution determined. Second, they are classified "ecologically," by habitat, associations and adaptations, and the environmental factors analyzed. Third, their relative abundance is determined, in the region as a whole or in each habitat separately, and estimates made of the percentages of evergreens, vines, parasites, plants belonging to certain families, etc. Fourth, the total bulk or weight of vegetation per unit area may be measured, together with the amount of new growth made in an average year, and the amount of water and other substances taken from the soil at the same time.

Although this is perhaps the usual and most convenient order, and also corresponds pretty well with the historical development of the science of plant sociology,* it is by no means a fixed order. Any one of the stages may be omitted, and the fourth, which though rather difficult is simple enough, could very well precede the first. And of course it is not to be assumed that the foregoing outline covers everything that needs to be known about vegetation. For example, it takes no account of generalizations about geographical distributions, times of flowering, colors of flowers, pollination and dissemination, studies of endemism and bibliographic history, and speculations about geological history and succession, all of which have contributed many pages to the botanical literature. Comparisons with similar or neighboring regions are always appropriate, too.

The region under consideration offers little attraction to the botanist who does not go beyond the first stage, and "cannot see the woods for the trees." As seems to be the case wherever *Pinus Taeda* (and the same might be said of several other pines) is the prevailing tree,* nearly all the plants are of common and widely distributed species, which have been described long ago. In the second stage, very little has been done in this region, largely because of inherent difficulties which will be explained below under the head of vegetation. This paper is chiefly concerned with the third stage, determining the relative abundance of the species in the region as a whole, which is done by means of notes accumulated during about seventy-five hours of field work. For the fourth stage, volumetric and dynamic studies, very few accurate data are available as yet for this or any other part of the world, but some rough estimates are attempted, to illustrate a method which should be followed in all future critical studies of vegetation. For it cannot be disputed that the annual growth of vegetation, and particularly the amount of food taken from the soil in a given time, is closely correlated with enviromental factors, and should be a better indication of soil fertility than any static studies of vegetation, whether qualitative or quantitative.

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* See Torreya 16: 138. June, 1916.

Location and boundaries of the region. The *Pinus Taeda* belt proper of the Atlantic coastal plain, as mapped by the writer a few years ago† (in FIG. 1 the same map is reproduced), is regarded as bounded on the north by the James an Appomattox Rivers. From Petersburg, Va., to the vicinity of Rocky Mount, N. C., it borders the fall-line, which there (as all the way across Virginia) runs just about north and south. Thence to near Fairfax, S. C., it passes northwestward into a belt of low red hills, a continuation of the Eocene red hills of Georgia, Alabama and Mississippi. From Fairfax to near Charleston it is bounded on the south by the pine-barrens with *Pinus Elliottii;* thence to near the mouth of the Santee River it is separated from the coast by a narrow coast strip, with marshes, islands, and a good deal of silty soil. From Horry County, S. C., to Onslow County, N. C., it passes gradually southeastward into the Wilmington or Cape Fear pine-barrens, with a much larger proportion of *Pinus palustris* and less *P. Taeda*. From Carteret County, N. C., to Nansemond County, Va., the Nansemond escarpment, parallel to the Virginia fall-line,* separates it from the region of oak and beech flats with more silty soil, in which Dismal Swamp is situated. In South Carolina the belt under consideration corresponds approximately with the "upper pine belt" of Hammond and other nineteenth century geographers.

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* See Torreya 7: 44-45. 1907; 9: 217. 1909. This applies to habitats, though, rather than to regions. For example, *Pinus Taeda* is the commonest tree in the Apalachicola bluff region of Middle Florida (see 6th Ann. Rep. Fla. Geol. Surv. 212-215, 353, 355), where many rare plants grow; but the pine is mostly near the top of the bluffs and the rare plants lower down.

† Bull. Torrey Club 37: 407, 592. 1910-11.

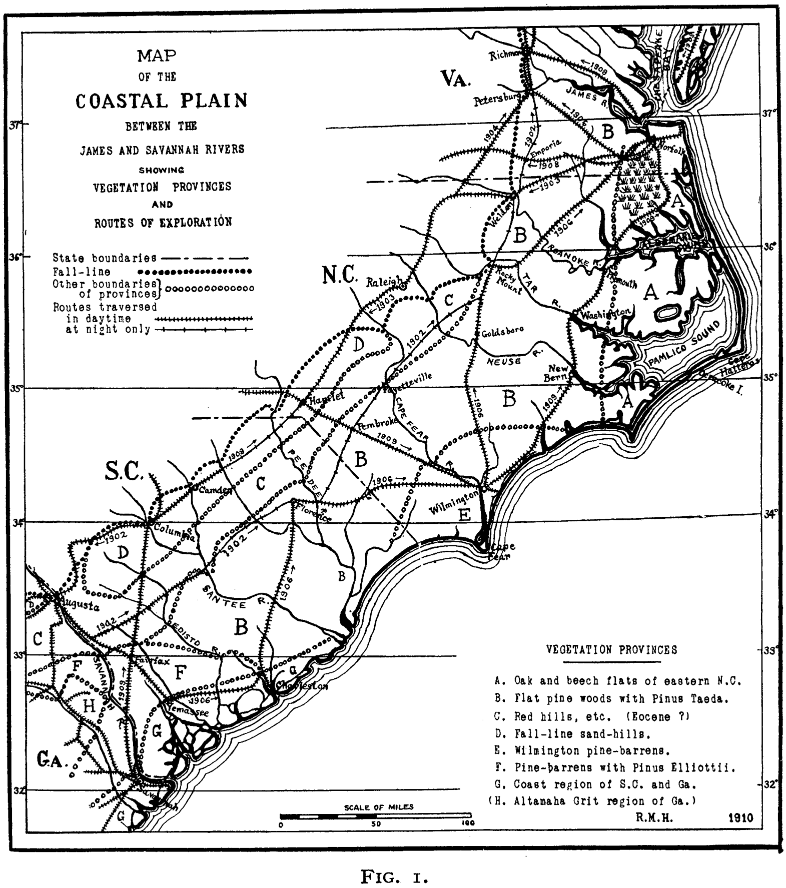

FIG. 1.

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* See Hobbs, Rep. 8th Int. Geog. Cong. (1905), line III on map opposite p. 196.

In the present paper the red hill belt lying just southeast of the fall-line sand-hills in the Carolinas is combined with the flatter and more sandy *Pinus Taeda* belt, being connected with it apparently by imperceptible gradations, and not differing much in vegetation. The total area involved is about 28,000 square miles. The most important literature on the region was summarized by the writer in 1907.* Since then there have been published several more government soil surveys, a report on the geology of the coastal plain of North Carolina,† Coker's Plant Life of Hartsville, S. C.,‡ and Ashe's monograph on loblolly or North Carolina pine.§ C. S. Chapman's "A working plan for forest lands in Berkeley County, South Carolina,"|| which was cited in my 1907 paper, will be referred to more specifically below.

Topography and hydrography. The altitude ranges from sea-level to about 300 feet. The topography is gently undulating in the red hills and nearly flat elsewhere, with few railroad cuts deep enough to obstruct the view of the traveler on a passenger train. There are bluffs near some of the rivers, but all the streams are bordered at least on one side by swamps, whose width is approximately proportional to the size of the stream. The rivers which rise in the Piedmont region are muddy, but the smaller streams which are confined to the coastal plain are not, except in prolonged wet weather. In the flat areas are many very shallow depressions, which will be referred to again under the head of vegetation. The ground-water is nearly everywhere close enough to the surface to be reached by well-sweeps and suction pumps.

Soils. The average soil might be described as a grayish sandy loam, varying toward red clay in the higher portions, and purer sand near some of the rivers. According to the government soil surveys hitherto published for this region (none for Virginia, about nine for North Carolina and eight for South Carolina), the eight commonest types of soil in the North Carolina portion are

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* Bull. Torrey Club 34: 351–353. 1907.

† N. C. Geol. Surv., Vol. 3. 552 pp. "1912." (Published about the middle of 1913.)

‡ See Torreya 13: 139–144. 1913.

§ N. C. Geol. Surv. Bull. 24. 169 pp., 27 pl. 1915.

|| U. S. Bur. Forestry Bull. 56. 62 pp., 4 plates & map. "1905." See Bull. Torrey Club 34: 352 (5th footnote), 360 (4th footnote). 1907.

"Norfolk fine sandy loam,"* "Norfolk sandy loam," "Swamp," "Norfolk sand," "Portsmouth fine sandy loam," "Portsmouth sand," "Portsmouth sandy loam," and "Norfolk fine sand"; and in the South Carolina portion "Norfolk sandy loam," "Swamp," "Portsmouth sandy loam," "Norfolk sand," "Coxville fine sandy loam," "Norfolk fine sandy loam," "Portsmouth fine sandy loam," and "Orangeburg fine sandy loam." This sequence should not be taken too literally, for the areas that have been surveyed may not be perfectly typical, and moreover, there are all possible gradations between adjacent soils, and similar soils are very liable to be classified a little differently by different men in neighboring areas, or even by the same men in different years. But it will suffice to show the prevalence of gray sandy loams and of swamps, and the scarcity of reddish and distinctly clayey soils. The reddish "Orangeburg" soils are perceptibly commoner in South Carolina than farther northeast.

The physical composition of the soil may also be illustrated by disregarding the more or less arbitrary series names (thus eliminating much of the "personal equation") and summing up the ten commonest texture classes, with their percentages. As in the plant list farther on, the column of percentages preceding the names is for the whole area, and the others for separate states as indicated.

	SOIL TYPES	N. C.	S. C.
31.2	Sandy loam	26.1	37.0
22.4	Fine sandy loam	30.0	12.7
15.0	Sand (including sand-hill)	13.9	16.0
14.0	Swamp, muck, etc.	14.8	12.6
3.8	Fine sand	3.8	3.8
3.0	Clay	1.8	4.2
2.7	Coarse sandy loam	1.5	4.1
2.4	Coarse sand	2.2	2.5
2.3	Loam	1.1	3.8
1.5	Very fine sandy loam	2.1	0.7

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* For the benefit of readers who are not familiar with the system of classification used by the U. S. Bureau of Soils it should be explained that the "Norfolk" series includes grayish coastal plain soils with friable yellowish subsoils, the "Orangeburg" gray, red or brownish soils with sandy clay subsoils, and the "Portsmouth" damp blackish more or less peaty soils with flat or slightly depressed surface. "Swamp" is usually applied to permanently saturated soils, but does not include all kinds of swamps, some of which have been described under other names, especially in later years.

Data for estimating the average chemical composition of the soil are rather meager. In the Tenth Census, vol. 6, pp. 504 and 556, are analyses of seven soils from this region (five from North Carolina and two from South Carolina), made by Hilgard's five-day acid digestion method, which seems to give results more consistent with the vegetation and crops than any earlier or later method. Details of the locality, depth, vegetation, etc., of each soil are given in the work mentioned (under Nos. 1 and 9 on page 504 and 11, 13, 15, 17 and 19 on page 556), and need not be repeated here. The averages of the seven analyses are given below. (With so few samples from South Carolina and none from Virginia it would hardly be worth while to give the averages for each state separately.)

	Per cent.
Water and organic matter	2.940
Potash (K_2O)	.125
Soda (Na_2O)	.052
Lime (CaO)	.079
Magnesia (MgO)	.076
Phosphoric acid radicle (P_2O_5)	.082
Sulphuric acid radicle (SO_3)	.085
Brown oxide of manganese (Mn_3O_4)	.068
Peroxide of iron (Fe_2O_3)	1.684
Alumina (Al_2O_3)	3.375
Soluble silica	2.704
Insoluble matter	88.844

These figures of course will mean little to one who is not accustomed to interpreting soil analyses, but those who are sufficiently interested may find it worth while to compare them with similar analyses from other states published in the same work and copied by the writer in recent easily accessible publications.* Even yet the significance of some of the figures cannot be explained, for lack of knowledge of the functions of some of the soil constituents in plant physiology; but there is no doubt that these soils are below the average for the United States in fertility.

It seems very probable that the Virginia portion of this belt has a higher proportion of potassium in its soil than the rest, on account of the proximity to metamorphic rocks and the drier summers, and more humus on account of the richer soil and less frequent fires. South Carolina is probably above the average in calcium, phosphorus and iron, on account of the occurrence of those elements in the underlying strata.

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* Bull. Torrey Club **40**: 380–391. 1913; **41**: 555. 1914; Rep. Fla. Geol. Surv. **6**: 195, 230, 269, 328. 1914; **7**: 123. 1915.

Another pretty good indication of soil fertility or the lack of it is the density of population, proportion of "improved land," and the annual expenditure per acre for fertilizers.* In the table below these data are given for the portions of the belt under consideration in each state, and also for the whole of each state and the United States, as computed from the reports of the 10th and 13th censuses.†

Areas	Inhabitants per square mile		Percentage of improved land		Expenditure for fertilizer per acre	
	1880	1910	1880	1910	1879	1909
Pinus Taeda belt:						
Virginia	29.4	40.7	25.9	28.1	$0.45	$1.89
North Carolina	28.8	42.0	19.8	27.2	.41	2.67
South Carolina	27.5	41.0	18.4	30.0	.73	3.47
Whole states:						
Virginia	37.7	51.2	33.0	38.3	.25	0.70
North Carolina	28.7	45.3	20.8	28.2	.33	1.39
South Carolina	32.0	49.7	21.2	31.3	.64	2.49
Whole United States	16.9	30.9	15.0	25.1	.10	0.24

These statistics ought to make it plain enough that the soil of the *Pinus Taeda* belt is less fertile than the average of the states in which it lies, and that in this belt the soil fertility tends to decrease a little southward. The great increase in the use of fertilizers between 1880 and 1910 probably does not indicate soil exhaustion so much as that the greatly increased output of the nitrate, phosphate and potash mines in other parts of the world, together with the improvement of transportation facilities, makes it possible to cultivate with profit much poorer soils than formerly.

Climate. As far as climate is concerned it will probably suffice for present purposes to give for one station in each state the mean temperature for January, July and the year, in degrees Fahrenheit, the average annual precipitation, in inches, and the percentage of it that comes in the four warmest months (June to September) and six warmest months (May to October). The stations selected are Williamsburg, Va., Goldsboro, N. C., and Blackville, S. C., at each of which records have been kept for more than twenty years. The figures have been computed from the annual summaries of the U. S. Weather Bureau for 1913, except that a few obvious typographical errors have been corrected with the aid of the 1912 summaries. There happens to be no station within the Virginia portion of the *Pinus Taeda* belt with a sufficiently complete record, but Williamsburg is only a short distance away, on the north side of the James River.

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* See Science II. **42**: 500–503. Oct. 8, 1915.

† For some similar statistics for other southeastern states and their economic significance, with a map of the pine-barren region, see Journal of Geography **14**: 42–48. Oct. 1916.

Stations and length of record	Mean temperature			Average Precipitation		
	Jan.	July	Annual	Annual	4 mos.	6 mos.
Williamsburg, Va., 22 years....	38.4°	76.8°	57.1°	49.18	38.6%	51.9%
Goldsboro, N. C., 44 years.....	42.3°	79.8°	61.1°	51.85	45.0%	60.0%
Blackville, S. C., 25 years......	46.4°	81.7°	64.4°	47.47	44.3%	58.3%

The milder winter southward is of course not surprising. The proportion of summer rain is higher here than in most places a little farther inland, but lower than in the neighboring Cape Fear pine-barrens.* The wetness of the summers in North Carolina, especially as compared with Virginia, is significant, and helps explain some of the differences in soil and vegetation.

Vegetation. The prevailing type of upland vegetation in this region resembles the typical pine-barrens farther south except in having more *Pinus Taeda* than *Pinus palustris*, more deciduous trees, and more shrubs. The flat areas and shallow depressions previously mentioned generally have either pocosin or cypress pond vegetation, the former being commonest in North Carolina (but more characteristic of the Cape Fear pine-barrens) and the latter in South Carolina.† Both alluvial and non-alluvial swamps, of several kinds, are of frequent occurrence. There is a little hammock vegetation near some of the streams.

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* For similar data for other places see Bull. Torrey Club **37**: 415–416. 1910; **41**: 556–557. 1914; Rep. Fla. Geol. Surv. **6**: 182–183. 1914.

† The "savannas" described by Chapman and the "bays" described by Coker, in the works on South Carolina vegetation already cited, must be very similar to pocosins, while Chapman's "pocosins" and Coker's "savannas" seem to be essentially cypress ponds. This does not necessarily indicate that these authors used the terms incorrectly, but rather that local usage varies from place to place. Readers who are not familiar with the term "pocosin" can find references in Bull. Torrey Club **37**: 415 (first footnote). 1910; and New Internat. Encyc. II. **18**: 761. 1916.

Owing chiefly to the general flatness of the country it is very difficult to draw a sharp line between different habitats or even between upland and lowland vegetation. There are many places where such "xerophytes" as *Pinus palustris*, *Quercus marylandica* and *Aristida stricta* grow within a few feet of moist-pine-barren plants like *Eupatorium rotundifolium*, *Chondrophora nudata* and *Habenaria ciliaris*, apparently in the same soil and with almost exactly the same amount of moisture. The activities of farmers and lumbermen during the last two centuries have complicated matters still further. About 30 per cent. of the area is now under cultivation, and therefore devoid of natural vegetation, considerable areas are occupied only by weeds, and the remaining forests have been robbed of their largest trees. For these reasons, and also because the superficiality of my observations does not warrant attempting such details, the vegetation is studied collectively, without separating the habitats. The frequency of fire has not been specially investigated, but it is doubtless less than in typical pine-barrens. At the present time fire is probably less frequent in any one spot than it was a century ago, on account of the numerous fields, roads, etc., that serve as barriers.

Summary of field work. The plant census below is made up from notes taken on several trips between New York and the states beyond the Savannah River, as follows. The arrangement is chronological, and references to places where some of the trips have been written up are given in parentheses.

June 11, 1903. Suffolk, Va., to Weldon, N. C., by the Seaboard Air Line. (Torreya **3**: 121–123. Aug. 1903.)

Nov. 17, 1905. Laurel Hill to Pembroke, N. C., by the Seaboard Air Line, and back on foot as far as Laurinburg. (Torreya **6**: 41–45. March, 1906.)

July 25, 1906. Savannah River (a few miles below Augusta) to Allendale, S. C., by the Charleston & Western Carolina Ry. (Bull. Torrey Club **34**: 351–377; **37**: 411. The first reference also applies to the other 1906 dates below.)

July 26, 1906. Ashley Junction to Florence, S. C., by the Atlantic Coast Line.

July 27, 1906. Florence, S. C., to Lake Waccamaw, N. C., by the Atlantic Coast Line.

July 28, 1906. Wallace (about 35 miles north of Wilmington) to Rocky Mount, N. C., and Suffolk, Va., by the Atlantic Coast Line.

July 30, 1906. Suffolk to Petersburg, Va., by the Norfolk & Western Ry. (about 47 miles an hour).

July 19, 1908. Suffolk to Emporia, Va., by the Southern Ry. (Torreya **9**: 219–221, 223–226. Nov. 1909.)

July 26, 1909. On the Seaboard Air Line in southwestern South Carolina from the Salkehatchie River to the North Fork of the Edisto. (Bull. Torrey Club **37**: 403–406, 411, 413–414, 418–420. 1910. This covers the work of the next two days also.)

July 27, 1909. Laurel Hill to Rosindale, N. C., by the Seaboard Air Line, and Verona to New Bern by the Atlantic Coast Line.

July 28, 1909. New Bern to Mackey's Ferry, N. C., by the Norfolk & Southern Ry. (now Norfolk Southern R. R.).

March 4, 1910. Perry to Allendale, S. C., by the Southern Ry. (Bull. Torrey Club **38**: 225–226. 1911.)

Aug. 22, 1913. Aiken to Ashley Junction, S. C., by the Southern Ry., with a stop of about an hour at Branchville, which allowed some observations on weeds. (Torreya **16**: 243. 1916.) Ashley Junction to Florence, S. C. (same route as on July 26, 1906) later in the day.

Aug. 23, 1913. Florence, S. C., to Parkton, N. C., and Fayetteville to Selma, N. C., by the Atlantic Coast Line. Selma to Goldsboro by the Southern Ry. Goldsboro to Beaufort, N. C., by the Norfolk Southern R. R., but note-taking interrupted by darkness near Mansfield, about 89 miles from Goldsboro.

Aug. 26, 1913. Beaufort to Kinston, N. C., by the Norfolk Southern R. R., and on foot from Kinston to Dover and the big pocosin near by. (See Pop. Sci. Monthly **85**: 354. Oct. 1914.)

Aug. 27, 1913. Kinston to Halifax, N. C., by the Atlantic Coast Line. (Notes taken later in the day along or near the fall-line north of Halifax are not counted here.)

March 3, 1914. North Fork of the Edisto to the Salkehatchie River in South Carolina, by the same route as on July 26, 1909, at the rate of about 44 miles an hour.

Dec. 16, 1915. Florence, S. C., to Pembroke, N. C., by the Atlantic Coast Line, and on foot along the Seaboard Air Line for a few miles northwest of Pembroke, to get one of the same plants seen there in 1905.

These trips together comprise about 1,560 miles of railroad travel in 53 hours (including perhaps 200 stops of half a minute or more at stations), and 40 miles of walking in 21 hours; and touch about five-sixths of the counties in the whole region. By states the field work might be summed up as follows: Virginia, one day in June and three in July; North Carolina, one in June, four in July, three in August, one in November, one in December; South Carolina, two in March, four in July, two in August, one in December. If observations could have been made in April, May, September and October the list of herbs would be more complete and accurate, but it is not likely that any tree that makes up as much as 1 per cent of the vegetation has been overlooked, except in cases of closely related species that are difficult to distinguish.

Methods of Analysis. Notes on the vegetation were taken on practically every mile, and from these the percentages given below have been calculated. As car-window notes cannot do justice to the abundance of some of the conifers, I have arbitrarily multiplied my figures for *Pinus Taeda* and *P. palustris* by 5 and for other conifers by 3 before calculating the percentages. The figures for *Cornus florida*, *Salix nigra*, *Oxydendrum*, *Carpinus* and *Planera* have been divided by 2 on account of the small size of those trees, for the object of this study is to analyze the vegetation volumetrically. The figures for a few still smaller trees, or large shrubs (listed after the regular trees) have been divided by 10, those for ordinary shrubs and woody vines by 100, and those for herbs by 500.* Species seen less than five times, which are presumed to make up a wholly insignificant part of the total vegetation, are omitted, as are all bryophytes and thallophytes, which are still smaller and less conspicuous, on the average, than vascular herbs. The fact that nearly all my walking in this region has been done in North Carolina tends to exaggerate the shrubs and herbs in the middle portion, but allowance is made for that in the generalizations which follow the list.

These percentages of course cannot be guaranteed to be accurate within 10 per cent., but they are reasonably consistent with pre-conceived notions and known facts. In C. S. Chapman's report on Berkeley County, S. C., previously mentioned, there is a multitude of detailed statistics from which the percentages of the commoner trees in that particular area can be computed, and that serves as a check on my results. But his figures cannot be taken as representative of the whole *Pinus Taeda* belt, for several reasons. In the first place, his area is too small and too far from the center to be thoroughly typical, and being the property of a lumber company it probably contains more pine than the average. Second, some of the species are wrongly identified,† and some very common ones, such as *Pinus serotina* and *Quercus marylandica*, are omitted from the statistics though mentioned as occurring.

The species are arranged in order of abundance in the region as a whole, but the percentages are given separately for each of the three states involved, in order to bring out certain interesting features of local distribution. The total percentage is given first, then the name of the species, its usual habitat in the region, and the percentages for the three states. Percentages too small to be represented without using too many decimal places are replaced by 0, but where a species has not been seen at all in one of the states the space is left blank. Percentages are given for herbs only in the case of a few of the most abundant species, for to attempt it for all of them would be a refinement wholly unwarranted by my crude methods, and would require too long decimals. The highest number in each line, if it is reasonably certain that more thorough exploration will not overturn its plurality, is printed in heavier type, so that the reader can run down one column at a time and pick out the characteristic species for each state. The names of evergreens are printed in heavier type (in the case of semi-evergreens only the specific name), and those of weeds enclosed in parentheses.

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* This is a modification of a method described in the 6th Annual Report of the Florida Geological Survey, pp. 177–180.

† See Bull. Torrey Club 34: 352. 1907.

LIST OF PLANTS

TREES

			Va.	N. C.	S. C.
46.4	**Pinus Taeda**	Nearly everywhere	**58.1**	49.9	40.4
16.4	**Pinus palustris**	Driest soils	0	12.1	**25.6**
6.2	**Pinus serotina**	Damp sandy places	1.0	**8.3**	4.7
3.7	Taxodium distichum	Richer swamps	**8.7**	3.3	3.1
3.4	Liquidambar Styraciflua	Various habitats	**5.5**	3.7	2.6
3.3	Nyssa biflora	Ponds and swamps	1.8	**4.0**	2.9
3.3	Taxodium ascendens	Ponds and small swamps	—	3.1	**4.5**
1.7	Quercus marylandica	Driest soils	0.8	1.8	1.7
1.6	**Pinus echinata**	Driest soils	**7.8**	0.7	1.3
1.5	Liriodendron Tulipifera	Branch-swamps mostly	**2.5**	1.6	1.3
1.4	Acer rubrum	Swamps	1.0	**1.7**	1.2
1.4	**Magnolia glauca**	Non-alluvial swamps	1.8	1.7	1.1
0.8	Quercus falcata	Dry soils	0.9	1.1	0.4
0.8	Quercus Catesbaei	Dry sandy soils	0.1	0.5	**1.2**
0.6	Nyssa uniflora	Alluvial swamps	**1.9**	0.5	0.5
0.6	Cornus florida	Uplands	**0.9**	0.8	0.3
0.5	Quercus alba	Richer soils	**1.9**	0.7	0.1
0.5	Quercus Phellos	Low grounds mostly	0.3	0.5	0.6
0.5	Salix nigra	Along streams mostly	**0.9**	0.6	0.4
0.4	Quercus **nigra**	Low grounds mostly	0.2	0.3	**0.5**
0.3	Quercus stellata	Uplands	0.2	0.4	0.3
0.3	Betula nigra	Along creeks and rivers	**0.5**	0.3	0.3
0.3	Oxydendrum arboreum	Uplands	**0.6**	0.4	0
0.2	**Ilex opaca**	Hammocks, etc.	**0.6**	0.2	0.2

0.2	Fagus grandifolia	Hammocks, etc.	0.2	0.2	0.1
0.2	(Diospyros virginiana)	Old fields, etc.	0.5	0.2	0.1
0.2	Fraxinus caroliniana	Swamps	—	0.1	0.2
0.1	Quercus Michauxii	Bottoms, etc.	0	0.1	0.2
0.1	Hicoria alba?	Richer soils	—	0.1	0.2
0.1	Hicoria aquatica	Alluvial swamps	0.1	0.1	0.2
0.1	Platanus occidentalis	Alluvial swamps	0.5	0.1	0.1
0.1	Quercus cinerea	Sandy uplands	—	0.1	0.2
0.1	**Gordonia Lasianthus**	Non-alluvial swamps	—	0.2	0
0.1	**Juniperus virginiana**		—	0.1	0.1
0.1	Populus heterophylla	Alluvial swamps	—	0	0.1
0.1	Quercus lyrata	Alluvial swamps	—	0	0.1
0.1	Planera aquatica	Alluvial swamps	—	—	0.2
0.1	**Quercus laurifolia**		—	0	0.1
0	Carpinus caroliniana	Bottoms, etc.	—	0.1	0

(and about 23 others)

SMALL TREES OR LARGE SHRUBS

.04	(Prunus angustifolia)	Old fields, etc.	0	.03	.05
.02	(Sassafras variifolium)	Old fields, etc.	0	.02	.02
.01	Persea pubescens	Non-alluvial swamps	—	.01	—

(and 5 others)

WOODY VINES

.005	**Smilax laurifolia**	Non-alluvial swamps	—	.01	0
.001	**(Lonicera japonica)**	Roadsides, etc.	—	0	0
.001	Tecoma radicans		0	0	0
0	Smilax Walteri	Swamps	—	0	0

(and about 8 others)

SHRUBS

.014	**Arundinaria tecta**	Low grounds	.02	.02	.01
.012	**Myrica cerifera**	Richer soils	.02	.01	.01
.011	Alnus rugosa	Swamps	.02	.01	.01
007	Clethra alnifolia	Damp sandy soils	.01	.01	.01
.007	**Ilex glabra**	Damp sandy soils	.01	.01	0
.006	Cyrilla **racemiflora**	Swamps	—	.01	—
.006	**Phoradendron flavescens**	On hardwood trees	.01	.01	.01
.006	Rhus copallina	Uplands	01.	.01	0
.004	Quercus pumila	Pine-barrens	—	0	.01
.003	**Magnolia glauca***	Low pine-barrens	—	0	0
.002	Liquidambar Styraciflua	Low grounds	0	0	0
.001	Viburnum nudum	Branch-swamps, etc.	—	0	0
.001	Aralia spinosa	Richer soils	—	0	0
.001	**Pieris nitida**	Pocosins, etc.	—	0	0
.001	(Diospyros virginiana)		0	0	0
.001	(Rubus cuneifolius)	Roadsides, etc.	0	0	0
.001	Cephalanthus occidentalis	Swamps and ponds	—	0	0

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* See Bull. Torrey Club 34: 371–372. 1907.

.001	**Zenobia cassinifolia**	Pocosins, etc.	—	0	—
.001	Decodon verticillatus	Swamps	—	0	—
.001	**Baccharis halimifolia**	Low grounds	—	0	0
.001	**Myrica pumila**	Pine-barrens	—	0	0
0	**Hypericum fasciculatum**	Cypress ponds, etc.	—	0	0
0	**Ascyrum stans**	Damp sandy places	—	0	—
	(and about 25 others)				

Herbs

.005	Eupatorium rotundifolium	Low pine land	.001	.005	.005
.003	(Helenium tenuifolium)	Roadsides, etc.	0	.003	.003
.002	**Tillandsia usneoides**	On trees	—	.001	.005
.002	Sarracenia **flava**	Low pine-barrens	—	.003	.001
.002	Chondrophora **nudata**	Low pine-barrens	—	.003	.001
.002	(Leptilon canadense)	Fields and roadsides	0	.002	.001
.001	Pteridium aquilinum	Pine lands	.001	.001	.002
.001	Aristida **stricta***	Pine-barrens	—	.002	0
.001	Polygala lutea	Low pine-barrens	.001	.002	0
.001	Lespedeza capitata sericea	Pine lands	—	.001	.001
.001	(Syntherisma sanguinale)	Fields, etc.	0	.001	.001
.001	(Senecio tomentosus)	Roadsides, etc.	.006	.001	0
.001	Rhexia Alifanus	Low pine-barrens	—	.001	0
.001	**Chrysopsis graminifolia**	Uplands	.001	.001	.001
.001	Scirpus Eriophorum	Low grounds	0	.001	.001
.001	Habenaria ciliaris	Low pine land	0	.001	0
.001	(Euthamia caroliniana)	Roadsides, etc.	—	.001	0
.001	Osmunda cinnamomea	Low grounds	0	.001	.001
.001	Polygala ramosa	Low pine-barrens	0	.001	—
.001	(Ambrosia artemisiifolia)	Fields and roadsides	0	.001	.001
.001	Marshallia graminifolia	Low pine-barrens	—	.001	0
.001	Panicum hemitomon	Shallow ponds, etc.	—	0	.001
0	Campulosus aromaticus	Low pine-barrens	—	.001	0
0	Habenaria blephariglottis	Edges of swamps	—	.001	—
0	Erianthus sp.	Pine woods	—	.001	0
0	Eriocaulon **decangulare**	Low pine-barrens	—	.001	0
0	Anchistea virginica	Around ponds, etc.	—	.001	0
0	Afzelia cassioides	Pine lands	—	0	.001
0	Lilium Catesbaei	Low pine-barrens	—	.001	0
0	Polygala **cymosa**	Cypress ponds	—	0	.001
0	(Acanthospermum australe)	Roadsides, etc.	0	.001	0
0	Andropogon scoparius?	Uplands	0	0	.001
0	Eupatorium purpureum	Branch-swamps	0	0	0
0	Vernonia angustifolia	Dry pine-barrens	—	0	0
0	**Nymphaea sagittifolia**	Creeks and small rivers	—	.001	0
0	(Rhynchospora inexpansa)	Low grounds	.001	.001	—
0	Mesadenia lanceolata	Low pine-barrens	—	—	.001
0	Xyris sp.	Low pine lands	.001	0	0

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* See Bull. Torrey Club **37**: 601–602. 1911.

o	(Stenophyllus floridanus)	Cultivated fields	—	—	.001
o	Oxypolis filiformis	Cypress ponds, etc.	—	o	o
o	Pontederia cordata	Cypress ponds, etc.	—	o	o
o	Typha latifolia	Marshes and ditches	o	o	o
o	(Diodia teres)	Roadsides, etc.	—	o	o
o	(Gnaphalium obtusifolium)	Old fields	—	o	.001
o	Eupatorium verbenaefolium	Low pine land	—	o	—
o	Andropogon sp.		—	o	o
o	Habenaria cristata?	Low pine land	—	o	o
o	(Agalinis fasciculata?)	Old fields	—	o	o
o	Solidago sp.		—	o	o
o	(Chaetochloa sp.)		—	o	o
o	Rhynchospora axillaris	Low pine-barrens	—	o	—
o	(Eupatorium capillifolium)		.001	o	o
o	(Lespedeza striata)	Roadsides, etc.	—	o	o
o	Ludwigia pilosa	Ponds, etc.	—	o	o
o	Andropogon glomeratus?	Low grounds	—	o	o
o	Ionactis linariifolius	Dry woods	—	o	o
o	Monarda punctata		—	o	—
o	Carphephorus bellidifolius?	Pine lands	—	o	—
o	Agalinis linifolia	Cypress ponds	—	o	o
o	(Eupatorium compositifolium)	Roadsides, etc.	—	o	o
o	(Sarothra gentianoides)	Old fields, etc.	—	o	o
o	**Lycopodium alopecuroides**	Low pine-barrens	—	o	—
o	Mikania scandens	Swamps	—	o	o
o	Laciniaria spicata?	Low pine-barrens	—	o	o
o	Zygadenus glaberrimus	Low pine-barrens	—	o	o
o	(Sida rhombifolia)	Roadsides, etc.	—	o	o
o	Mesosphaerum radiatum	Low pine-barrens	—	—	o
o	Iris **versicolor**	Low grounds	o	o	—
o	Helianthus angustifolius	Low pine land	—	o	—
o	(Chamaecrista fasciculata)	Old fields, etc.	—	o	o
o	(Polypremum procumbens)	Roadsides, etc.	—	o	o
o	Eriogonum **tomentosum**	Dry sand	—	—	o
o	Sabbatia lanceolata	Low pine-barrens	—	o	—
o	Dichromena latifolia	Low pine-barrens	—	o	o
o	Rhynchospora corniculata	Low grounds	o	o	o
o	Erianthus strictus	Low grounds	—	o	o
o	Juncus scirpoides	Low grounds	—	o	—
o	Cicuta Curtissii	Low grounds	o	o	—
o	(Cyperus rotundus)	Fields, etc.	—	o	o
o	Rhexia mariana?	Low grounds	o	o	—
o	**Nymphaea fluviatilis**?	River-swamps	—	o	o
o	Silphium compositum?	Dry pine land	o	o	o
o	Iris tripetala	Low grounds	—	o	—
o	Sarracenia purpurea	Pocosins, etc.	—	o	—

(and about 160 others)

Just how much a census taken at the time of the discovery of America would have differed from this it is impossible to say. It is very likely, however, that *Pinus Taeda* has replaced *P. palustris* to a considerable extent through the influence of civilization, as claimed by Ashe and others; one of the reasons for the change probably being the diminishing frequency of fire, for *P. Taeda* is more sensitive to fire than *P. palustris* is.

The percentages of evergreens are for Virginia 69.4, North Carolina 73.6, South Carolina 75.7, and for the whole region 74.0. The correspondence between these figures is close enough to give confidence in the method used, and at the same time the differences are just what one would expect from the slight differences in soil fertility in the three states already pointed out.*

So many of the Ericaceae and Leguminosae are not readily recognizable from a moving train that it is hardly worth while to attempt to give statistics for these plants for each state separately, but for the whole region the proportion of Clethraceae, Ericaceae and Vacciniaceae among the shrubs seems to be about 12 per cent. and of Leguminosae and allied families among the herbs about 4 per cent. The figure for Ericaceae is the same as that already obtained for northern Florida† while that for Leguminosae is lower. It is reasonably certain that the Ericaceae are most abundant in North Carolina and the Leguminosae in South Carolina.

By contrasting the more characteristic plants of each division we can get some interesting facts. In the following table the species which are most abundant in the Virginia portion are listed in the first column, the same for North Carolina in the second, and for South Carolina in the third. They are arranged in order of abundance, just as in the preceding table. Those starred seem to be at least twice as abundant in the state indicated as in either of the other two.

This table confirms in a general way observations of a similar nature made in passing through the same three states in 1906, but taking in a larger and more diversified area.‡ The proportion

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* Previous estimates of evergreen percentages for parts of the Carolina coastal plain (summarized in Bull. Torrey Club 41: 563–564. 1914) are now believed to be too low.

† Ann. Rep. Fla. Geol. Surv. 6: 395. 1914.

‡ Bull. Torrey Club 34: 363–366. 1907.

VIRGINIA	NORTH CAROLINA	SOUTH CAROLINA
	Trees	
Pinus Taeda	*Pinus serotina	*Pinus palustris
*Taxodium distichum	Nyssa biflora	Taxodium ascendens
Liquidambar Styraciflua	Acer rubrum	*Quercus Catesbaei
*Pinus echinata	*Gordonia Lasianthus	Quercus nigra
*Liriodendron Tulipifera		Fraxinus caroliniana
Cornus florida		Quercus Michauxii
*Nyssa uniflora		Hicoria alba?
*Quercus alba		Hicoria aquatica
Salix nigra		Quercus cinerea
Oxydendrum arboreum		Populus heterophylla
Betula nigra		*Planera aquatica
*Ilex opaca		*Quercus lyrata
Diospyros virginiana		Juniperus virginiana
*Platanus occidentalis		Quercus laurifolia
	Small trees	
	*Persea pubescens	Prunus angustifolia
	Vines	
	*Smilax laurifolia	Tecoma radicans
	Smilax Walteri	
	Shrubs	
Myrica cerifera	Ilex glabra	Phoradendron flavescens
*Alnus rugosa	*Cyrilla racemiflora	*Quercus pumila
Rhus copallina	Magnolia glauca	Diospyros virginiana
Liquidambar Styraciflua	*Viburnum nudum	Baccharis halimifolia
	Aralia spinosa	*Hypericum fasciculatum
	*Pieris nitida	
	*Zenobia cassinifolia	
	Decodon verticillatus	
	*Ascyrum stans	
	Herbs	
*Senecio tomentosus	*Sarracenia flava	Helenium tenuifolium
Eupatorium capillifolium	*Chondrophora nudata	*Tillandsia usneoides
	Leptilon canadense	*Pteridium aquilinum
	*Aristida stricta	*Chrysopsis graminifolia
	*Polygala lutea	*Scirpus Eriophorum
	Lespedeza capitata sericea	Osmunda cinnamomea
	*Rhexia Alifanus	Ambrosia artemisiifolia
	*Habenaria ciliaris	*Panicum hemitomon
	*Euthamia caroliniana	Afzelia cassioides
	*Polygala ramosa	Polygala cymosa
	*Marshallia graminifolia	Andropogon scoparius?
	*Campulosus aromaticus	Mesadenia lanceolata
	*Habenaria blephariglottis	Stenophyllus floridanus
	*Eriocaulon decangulare	Oxypolis filiformis
	*Anchistea virginica	Typha latifolia
	*Lilium Catesbaei	Diodia teres
	(and 24 others)	(and 12 others)

of trees is evidently highest in Virginia, and of shrubs and perhaps herbs in North Carolina.

Without taking up undue space by considering each species separately, it may be said that those in the Virginia list are mostly species that prefer soils richer in potash or humus than the average of the region.* Those in the North Carolina list are largely plants of moist pine-barrens or sandy or peaty bogs, called "bog xerophytes" by some American ecologists, and "oxylophytes" by Warming. Some of those in the South Carolina list may be restricted in their northward distribution by temperature, as suggested in 1907. Others are characteristic of cypress ponds, and some apparently prefer more ferruginous or phosphatic soils than the average of the region. (This may apply especially to the genus *Quercus*, of which there is one in the first column, none in the second, and seven in the third.) Some of the herbs are weeds, but just why weeds should be more abundant in South Carolina is not apparent. It is probably by such comparisons as these, preceded by careful analyses of environmental factors, that we can make the most progress in discovering just what is the optimum environment for each species.

Volumetric and dynamic studies. From reports of foresters on more or less similar areas (which need not be cited here), the stand of timber at the present time may be estimated roughly as 6,000 board feet of lumber per acre. This is equivalent to 500 cubic feet; but to make allowance for slabs, sawdust, tops, saplings, bushes, etc., the latter figure should be just about doubled, making 1,000 cubic feet of wood per acre.

The average increment of partly culled forests of *Pinus Taeda* is at least 3 per cent. annually, and as that is the most abundant species in the region under consideration we will not be far wrong if we take 3 per cent. for the annual increment of the whole vegetation, which would make 30 cubic feet of wood per acre per year.

The dry wood of *Pinus Taeda* weighs 34 pounds per cubic foot, according to Sargent, but that of most of the other trees is heavier, so that we will assume the average weight to be 37 pounds, and that of the woody increment 1,110 pounds per acre.

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* Several of the same species were found a few years ago to be more abundant in the pine-barrens of Mississippi than in those of Georgia; doubtless for similar reasons. See Bull. Torrey Club 41: 563. 1914.

The percentage of ash in the wood is 0.26 in *Pinus Taeda*, but more in most of the other trees, say 0.32 on the average, which would make over three pounds of mineral matter taken each year from the soil by the wood alone. As the inorganic constituents of plants are chiefly concentrated in leaves and bark, and the herbs, which are renewed from the ground up every year, probably take as much from the soil per acre per year in such open forests as the trees do, we may safely multiply the last figure by forty or fifty, making something like 150 pounds per acre (equivalent to a layer of soil about 0.0005 inch deep) for the annual draft on the soil.

This is less than is taken from the soil by the average cultivated crop, even without fertilization, and it all goes back to the soil in the course of time, except what is removed by lumbermen and grazing animals or carried away by streams. Fire, though it destroys the humus and thus dissipates the nitrogen, at the same time accelerates the return of the mineral substances to the soil, and thus enables forests of the pine-barren type to do a large business on a small capital, so to speak. The gradual erosion of the whole surface, continually exposing deeper layers of soil, is probably sufficient to counteract the leaching and keep the soils from becoming steadily poorer.

The amount of water evaporated by average vegetation in moderately humid regions is said to be about 700 pounds to one pound of dry vegetable tissue, and if the total amount of vegetable matter produced in a year is four times the amount of new wood estimated above, or 4,440 pounds per acre, the water required for the region in question would be 3,108,000 pounds per acre, equivalent to about 16 inches of rain, or less than half as much as would evaporate from open water in that climate.*

The foregoing estimates are only crude approximations, but probably lie somewhere between half and double the correct figures; and when such a method is applied with skill and patience to the vegetation of different regions, or different habitats in the same region, it ought to yield some extremely significant results.

COLLEGE POINT, NEW YORK

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* See Transeau, Am. Nat. **39**: 885; Rep. Mich. Acad. Sci. **7**: 74. 1905.